

Teaching Engineering Ethics in the Classroom through a Town Hall Meeting Activity

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Abstract

Engineers often contribute to projects that impact many people and have ethical implications. Some may even move to a career of political advocacy and policy-making. However, most engineering curricula have a strongly technical focus and do not require students to think critically about ethical issues related to engineering. To bridge this gap, we developed a classroom-based town hall meeting activity that demonstrates the ethical issues that may arise when engineers are advocating for or helping craft public policies. Our town hall meeting scenario, which was set in a fictional tourist town called Rainbow Town, divided a class of twenty engineering students into groups of engineers, politicians, and voters. There were two opposing political groups and two engineering groups with competing interests. The voters had individual characters with varying careers and objectives. The town hall meeting was a debate on whether Rainbow Town should undertake a construction project that would bring jobs to the city, but could potentially adversely impact fish population at the town's natural heritage site, the main source of income for the town. The objective of the activity varied based on what role each student was playing. The politicians' job was to further the objectives of their own party while simultaneously keeping their voter base happy. The engineers' job was to help voters make an informed decision about which policy (or party) to vote for, while helping politicians craft the right policy. The voters' job was to protect their own livelihoods. Despite the simplicity of the town hall meeting scenario, the students wholeheartedly donned the mantle of their assigned role, taking the objectives of their role seriously. At the post-activity debrief, students commented that the activity was harder on the engineers since they had to prove everything with facts, but the politician groups did not.

1. Introduction

Individuals in the engineering profession work on projects that can have transformative effects on communities, societies and ways of life. However, due to the

nature of their projects, even a small mistake or misstep in their work can endanger the health, safety and well-being of hundreds of people. Hence, engineers must hold their moral and ethical principles to the highest prerogative. The Accreditation Board for Engineering and Technology (ABET) require that accredited engineering programs (2016-2017) prepare students to design systems, components or processes within "realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability", many of which are tied to ethics [1]. Moreover, students are also required to have an "an understanding of professional and ethical responsibility". However, most engineering curricula do not require students to think critically about ethical issues that may arise in their field. Moreover, while there is consensus that engineering ethics are essential for students across all engineering disciplines, there has been debate about appropriate teaching methods among engineering education society [2].

Newberry (2004) identified that there are some systematic barriers that interfere with engineering ethics education [3]. The main discrepancy is that students lack emotional engagement with the materials. To bridge this gap, we developed a classroom-based town hall meeting activity that demonstrates the ethics issues that may arise when engineers are working on real-life community projects or helping craft public policies. This activity was piloted in an engineering education graduate course at the University of Texas at Austin (UT) in the Spring of 2017. The course, which is called Teaching Engineering, is cross-listed in the Mechanical Engineering and STEM Education departments. In this iteration of the course it consisted of twenty-three graduate students from various engineering and science majors. The activity was set in a fictional city where economic activity centers around tourism. In the scenario, the city was deciding on whether to approve a multi-million-dollar project that would transform the economy of the city, but would potentially have far-reaching consequences on tourism. Students were randomly assigned different

stakeholder roles (politicians, engineers, and voters) in a town hall meeting setting to make a final vote on whether to approve the project. There were two opposing political groups and two engineering groups with competing interests. The voters were individual characters with varying careers and objectives. The objective of the activity varied based on what role each student was playing. The politicians' job was to further the objectives of their own party while simultaneously keeping their voter base happy. The engineers' job was to help voters make an informed decision about which policy (or party) to vote for, while helping politicians craft the right policy. The voters' job was to protect their own livelihoods.

We had three objectives for our activity. First, connect students with real-world engineering ethical issues on a personal level to increase their emotional engagement with the subject. The hope was that by role-playing as various stakeholders, students could see things from the 'other side of the table' and understand how the outcome of decisions can impact different groups in different ways. Second, help students utilize the stakeholder point-of-view to create solutions that maximize benefits and minimize costs fairly for all interest groups, regardless of personal views or vested interests. Third, allow students to understand the complexities and challenges involved when engineers work with politicians or other interest groups to design solutions. To evaluate the effectiveness of our activity in meeting our objectives, we had an extended debrief session with the study participants after the study. We also conducted an anonymous post-activity survey.

The remainder of the paper is organized as follows. In Section 2, we detail the methods employed in the town hall meeting activity. This includes the description of the fictional scenario that was utilized for the activity, the rules of the activity, and the post-activity survey collection method. Section 3 discusses the results of the activity and post-activity survey, and provides implications of our study. Finally, Section 4 summarizes the entire paper in the context of engineering education.

2. Methodology

We developed a town hall meeting scenario that would allow students to experience real world engineering ethics issues first hand. Roles were randomly assigned to students in the class and detailed handouts with descriptions of their roles provided (Appendix A). The roles can be broadly categorized as Engineers, Politicians and Voters, with subgroups within each category (Table 1). The town hall meeting scenario, which is about a fictional city called Rainbow Town, is as follows:

Rainbow Town is famous both for the breathtaking natural beauty of its valley and because it is the home of a

rare species of multi-hued fish locally known as Rainbow Fish. These fish, which inhabit Rainbow Lake, are an endangered species which can be found nowhere else in the world. Hence, Rainbow Town is a protected Natural Heritage site. Recently, there have been plans to construct a baseball stadium beside Rainbow Lake. The Orange Party and the Green Party, the political parties in town, are for and against the stadium construction respectively. Two groups of engineers, one group from an investment firm and one group from a consulting firm, have been hired to do some initial analyses on the proposed construction project. The residents of Rainbow Town are voters with different professions who will vote for one of the political parties based on their personal objectives. Each political party will try to convince the voters to support their stance.

2.1 Town hall meeting procedure and rules

We conducted the activity in two phases, with voting in each round (Figure 1).

In the first phase, students read the handouts pertinent to their own role, which laid out the objectives, motivations and personal history of the group or individual they were representing. After discussion with other members of their group (if any), they prepared their initial stances. Each politician group (Green Party and Orange Party) were given a chance to announce and justify their proposed party stance on the stadium construction to the voters. The politician groups did not have to support their statements with facts and could use rhetoric. This was followed by the two engineering firms (Investment Firm and Consulting Firm) releasing their analysis, in accordance with the specific objectives of their group. The engineering groups, unlike the political parties, had to support their statements with facts provided in the scenario. After hearing the initial reports from the politicians and engineers, each voter was then asked to verbally cast an initial vote on which party they wished to support and why. The voters were also given a chance to talk about any concerns they had with the politicians' policies. We intentionally chose an odd number of voters to avoid a tie.

Each group or individual had specific alliances to consider when fulfilling their objectives. The Orange Party, which supported the stadium construction, was allied with the investment firm which was also pro-construction. The Green Party, which was against construction, was allied with the consulting firm, which was providing an environmental assessment of the construction. Meanwhile, each individual voter had to consider their character's typical voting tendencies. Although voters could vote for any of two parties, their role descriptions contained their previous voting history. The previous voting history was designed in a way that an equal number of people typically voted for either party, with varying levels of adherence and support.

The levels of support were designed to favor neither party. Only one voter (teacher) had no party ties whatsoever. Hence, in the event of every other voter adhering to their previous voting preferences, the teacher would be the deciding vote (Figure 2).

The second phase started with cross-communication between groups. Having heard the voters' concerns, politicians could seek the advice of the engineering firms to come up with an adjusted stance that would appease more voters while still achieving their party objectives. This was done in an open discussion format, where voters could listen in and ask questions. After the discussion was over, each politician party delivered their adjusted policy stance. After hearing them out, the voters cast their final party vote via secret ballot.

Throughout the activity, there were several ground rules to ensure a smooth and seamless process. The students had to follow the time limits imposed by the moderators, respect talking opportunities of other players, and hide their role description sheet. In addition, politicians and engineers could utilize a 'fact-checking tool' to check the reliability of their stances. The fact-checking tool was a built-in feature of our activity that allowed students to obtain information related to the scenario from three sources: peer-reviewed journal articles, community statistical reports, and reputable news media. The students had to ask the moderators to obtain information from any of these three sources. The moderators would then provide the answer based on the state of knowledge of each source determined when we designed the activity.

2.2 Post-activity feedback

After the final vote, we had a 15-20 minutes debriefing session to discuss the results of the activity and give students a chance to share any insights they had gleaned from the experience. This gave everyone an opportunity to understand why the scenario had played out the way that it did and the reasoning behind the actions of players during critical moments in the activity.

We also conducted a post-activity survey to investigate the effectiveness and future applications of this activity. The survey contained five numeric point-scale questions and three open-ended short answer questions (Appendix B). The surveys were anonymous and did not tie any student to their individual responses.

3. Result and Discussion

During the initial vote, after the two politician groups provided the voters with their initial party stances and the two engineering groups delivered their technical reports, the Green Party came out on top with four out of seven votes (Orange Party = 2 votes; Undecided = 1 vote). However, this result was completely reversed in the final voting, after

politicians had a chance to revise their stance based on the concerns of the voters and the reports of the engineers. In the final vote, the Orange Party came out on top with six out of seven votes. The voting result is summarized in Table 2.

The Orange Party were able to utilize voter feedback and guidance from the engineering groups to create a final proposal that won over voters who had initially voted for the Green Party. The reasons for this voting reversal, as well as other curious observations from our activity, are provided in more detail in the following paragraphs.

3.1 The 'Performance Phenomenon'

In the beginning, there was some slight confusion as the nineteen engineering graduate students who participated in our activity read the descriptions of their assigned characters, but the students were able to quickly get adjusted to their roles. These roles were investor, consultant, politician or voter, with each voter having their own specific characters and interests. It surprised us how wholeheartedly the students donned the mantle of their assigned role, taking the objectives and interests of their role very seriously, and we dubbed this the 'performance phenomenon'. For the group of students role-playing as either the Engineering Investment firm or the Engineering Consulting firm, this phenomenon was not that surprising. Since these students were acting as the technical and professional experts from their respective 'firms', their roles were not that different from their actual careers as graduate research assistants or future industry engineers. However, the students in the two rival politician groups, regardless of their assigned party affiliation, were also very engrossed in their roles. The same applied to students assigned as voters, whose 'identities' such as fisherman, tourist guide, or local business owner did not necessarily reflect the students' own experiences. Some specific examples of the 'performance phenomenon' are in the proceeding paragraphs.

Both politician groups went to great lengths to meet their objectives. What we found significant was that they were even willing to bend the truth to meet their goals, since that was allowed in their role descriptions. The fact that the role players were in reality engineers trained to be objective became irrelevant in the face of what their role demanded. Below are examples of this phenomenon from both parties:

Green Party: After the voter's initial vote and feedback on the stadium construction, the two politician groups could confer with the engineering firms to get expert opinions on how to adjust their policy stances to suit their voters' preferences. During this time, a Green Party member was heard asking for the consulting firm's endorsement on the Green Party's updated policy stance in an aggressive tone. It appeared that to win voters, the Green Party was willing to

abandon the pretense of maintaining scientific integrity and instead pressed their agenda on the scientific community, as represented here by the engineering consulting firm.

The Orange Party: made bold promises to win over voters. Their final proposal for the stadium construction was quite ambitious, made to appease the diverse interests represented by the different members of the voter group. But their proposal was arguably elaborate to the point of being unfeasible. They proposed to build a stadium with the following add-ons: a Rainbow Fish aquarium, an on-site wastewater facility for treating water before disposal into Rainbow Lake, and a research and development lab. They envisioned stadium patrons viewing the Rainbow Fish while waiting for games to start, which would increase the popularity of the Rainbow Fish and boost fisherman livelihood. Their proposed onsite wastewater treatment facility would ensure there was no degradation of water quality in Rainbow Lake. In addition, the Research & Development facility would conduct research on the preservation of the natural ecology at Rainbow Town.

We did not give any physical or financial constraints to the politician's proposals, but regardless, the construction of a stadium with an attached wastewater facility, not to mention the aquarium and the R&D lab, would be a mammoth undertaking, especially in a small fishing town like in our scenario. The Orange Party did not explain *how* they would finance such an endeavor. Rather they used their lavish proposal to appease most of the different interest groups.

On the surface, the proposal seemed to be a win-win for everyone. Baseball fans would get their stadium, the construction industry would get a big new project, the tourism industry would get a new attraction, and environmentalists could not complain because of the new R&D facility and treatment plant. However, no one questioned the feasibility of the Orange Party's proposal, even though it was based entirely on speculation on several fronts. The Orange Party based their proposal on three assumptions: the proposed treatment plant would protect the Rainbow Fish; the proposed aquarium would boost the popularity of the Rainbow Fish; the proposal would be financially feasible. None of these assumptions were pointed out by the voters.

It is remarkable how much of this situation imitates real-life. Our political role players, much like politicians in real life, used their words instead of actions to impress interest groups. Yet, their 'constituents', who despite their roles were a group of graduate engineers, took these promises at face value seemingly without considering their practicality, and ended up voting for them. It appears that while trying to protect their imaginary livelihoods, the voters were willing to go with whatever that sounded convenient.

Our activity was designed so that the politician groups could use rhetorical devices or be dishonest if they wanted to, but it amazed us at how good both the politician groups were at finding loop-holes (e.g. the lack of specific financial and physical constraints) and how quickly they went into morally-grey areas (e.g. pressurizing engineers for an endorsement; creating a plan that will please voters without considering feasibility).

Does art imitate real life? Based on the results of the activity, we certainly think so. This was not limited to only the politician groups, but also applied to the voters and in a lesser degree, to the engineers. The voters were very protective of their livelihood and personal goals, which is not surprising but differed slightly from our expectations. Secretly, we had hoped that everyone would be more philanthropic and that they would choose the best solution for *everyone*, not just themselves. We had factored in the fact that the role-players were a group of analytical, practical engineers, and we thought that they would make decisions based on the facts, instead of being swayed by promises that sounded good on the surface. It turned out that despite being only a simulation, our scenario reflected how things get much more complicated in the real world. Facts and rhetoric get mixed up, and it is hard to make a cold judgement call. We had a small sample, but it seemed we were able to simulate some of the complexities in a real-world scenario during our activity.

3.2 The Fact-Checking Tool

The 'fact-checking tool' that we built into our activity provided some surprising insights. None of the students, including the politician groups, selected news media as a fact-checking tool. There are a few possible reasons for this. First, most of the participants in our activity were engineering graduate students, who are used to utilizing peer-reviewed journal articles and scientific reports in their work. Second, it could reflect the prevailing attitudes toward news media in society today, which have been marked by an air of distrust and suspicion. Moreover, we did not provide any specific ratings or reliability information about the news media in our fact-checking tool. This ambiguity was designed on purpose to throw some confusion among the groups.

The fact-checking tool was also an exercise on how the same information can be interpreted in different ways. At one point before the final vote, the Orange Party asked us, the moderators and the instruments of fact-checking, whether the Rainbow Fish population was currently stable or decreasing. We had not anticipated such a question and had not decided on this seemingly inane fact when we designed the scenario. As such, we hastily decided on the spur of the moment that the population of the Rainbow Fish was not

stable and was decreasing. It had already been established in the scenario that the fish were an endangered species and that, as both a natural heritage and the basis for the town's income, they had to be protected. Hence, we figured it did not matter. This statement later proved to be a key point in the argument of the Orange Party in favor of stadium construction. They argued that because the Rainbow Fish population was already in decline, the city needed to be more versatile in its sources of income and get tourists for other attractions, such as for baseball games. In the end, this won over some constituents that had previously voted for the Green Party, resulting in the 6-1 win for the Orange Party, even though they had originally been down 2-4. This is another example of how the politician groups, particularly the Orange Party, were able to utilize loopholes to their advantage and reinterpret facts to fit their narrative.

It is worth discussing here why we chose a fictional scenario over a real one for our activity, despite having a multitude of past real-world engineering ethics situations we could have picked. We wanted to have full control over the limitations and boundaries of the scenario and limit the information that students had, to imitate the fact that in the real world, decisions must be made in the face of limited knowledge. For example, the engineering groups did not know what specific water quality parameters the Rainbow Fish were most sensitive to, because that was an area of ongoing research. Also, we did not want students to have a bias toward any proposal or outcome based on prior knowledge.

3.3 Post-activity feedback

We conducted a 15-20 min post-activity debrief with all the participants and followed this up with an anonymous paper survey. Figure 3 illustrates the survey results. Reception to the town hall meeting was positive, with 75% of participants indicating that they would be likely to utilize such an activity in their own classrooms to teach engineering ethics, and 69% indicating that they would be likely to recommend the activity to other professors. The debriefing session ended up being quite critical to the project, because it was here that we were able to break down the results and obtain many of the key insights from the activity that are presented here in this paper. Many of the students had expected the Green Party to win, especially because of the initial vote, and expressed surprise that things had made a complete turn-around.

The fisherman was the only person who voted against the Orange Party. During the post-activity debrief, the fisherman explained that the reason he continued to support the Green Party was that he was not convinced by the Orange Party's assertion that the stadium would not adversely affect the Rainbow Fish population. The teacher, as the only

independent voter and a lover of science and reason, was the one person we were certain would not be swayed by rhetoric or promises. However, to our surprise, he was convinced to vote for the Orange Party because of their promise to build an R&D facility at the stadium, which in his view, was a win for science and reason.

In both the debriefing session and the paper survey, students mentioned that the activity was the most beneficial for the engineering groups, even though the results were interesting for everyone. Perhaps in future iterations of the activity, multiple scenarios can be utilized, with students switching roles between each scenario.

4. Conclusions

Engineers are trained to design solutions and present facts in an impartial and objective manner, and in doing so maximize the collective good for society. However, ethical dilemmas and real-world complexities can prevent them from performing to the best of their ability and achieving the best outcome for society. Based on the results of this project, we conclude that town hall meeting activities are one possible interactive format that can be used to demonstrate ethical issues that arise in engineering careers. Issues that are seemingly black or white on paper take on much more complex undertones when stakeholders with differing objectives and backgrounds come into play, because everyone typically looks out for their own interests. While it takes experience to fully understand and deal with these situations, town hall meeting activities or other similar role-playing activities can help bridge that gap in engineering curricula. Moreover, these activities force students to think about issues from the perspective of stakeholders, which can help them design solutions that are geared toward community needs.

We envision town hall meeting activities, such as in our study, being used in engineering design courses to take 'stakeholder input' into account. Since many design courses already require students to present initial design concepts and final design deliverables to the rest of the class, we think town hall meeting scenarios could be seamlessly integrated into the presentation process. During initial concept design, students would have to convince stakeholders about the merits of their design and address concerns. Then at the end of the course, students would have to launch their product or service to the stakeholders. The stakeholders could be real members from the community for whom the scope of the project is relevant – this would require some planning from the part of the course instructor to find such individuals. Alternatively, it could be student role players from the class, which would be an educational experience for the students.

Outside of engineering, the town hall meeting activity can be relevant in public policy and social science courses.

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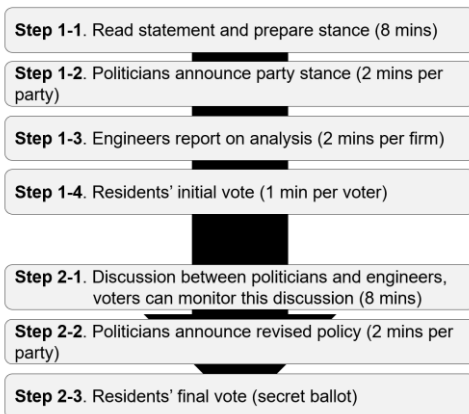


Figure 1: Breakdown of the stages of the town hall meeting activity

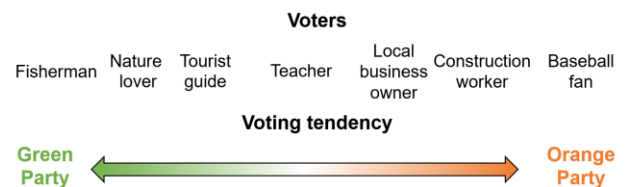


Figure 2: Voting tendency of the residents in the fictional city Rainbow Town

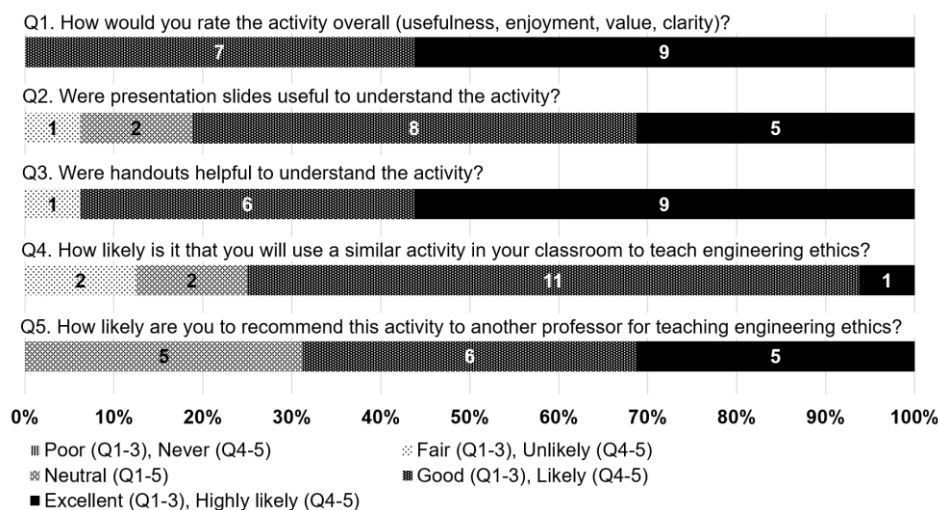


Figure 3: Survey results

Table 1. The simplified descriptions of the 11 roles in the Town Hall meeting scenario

Group/Role	Description
POLITICIANS - Based on their party affiliation, the politicians must collectively decide their stance on the construction of the baseball stadium. Each party consists of 4 students	
Green Party (4)	They tend to have policies that cater to environmental groups, since environmental groups form a large portion of their party base.
Orange Party (4)	People in the baseball industry are a supporter and donor of the Orange Party and they want to continue to receive their patronage.
ENGINEERS - Based on their company expertise, the engineers must give factual assessments on the baseball stadium construction. Each engineering group consists of 4 students	
Engineering Investment Firm (4)	Engineers in the investment firm must assess if it will be worthwhile to invest in the baseball stadium project at Rainbow Town. Local government is interested in hearing their assessment. They will consider a 25-year period to assess return on investment and assume that it will take 2 years to construct the stadium.
Engineering Consulting Firm (4)	Engineers in the consulting firm have been hired by the government to independently review and give an analysis of the plans to build a baseball stadium at Rainbow Town. They are expected to give a lifecycle analysis of the project considering economic, social, and environmental factors in a 25-yr period. They will assume that it will take 2 years for stadium construction.
VOTERS - Based on how the proposed policies by the politicians affects their personal objectives, voters have to decide which political party they support. There are 7 individual voters	
Fisherman (1)	Fishing has been their livelihood for decades and they would not be able to switch to a different profession if the fish became non-viable. Although Rainbow Fish are an endangered species, there is a small quota for fishing which allows them to be sold at aquariums. Since Rainbow Fish are so rare, fishermen obtain a lot of money per fish. Tend to vote Green Party.
Tourist guide (1)	They work as a guide for Rainbow Lake tours, showing people the Rainbow Fish and famous spots around the valley. It is a fun job, and since they are around people who are relaxed and have money on their hands, they get tipped well too. Tend to vote Green Party.
Nature lover (1)	They are an ecologist who is passionate about natural history, sustainability and the environment. They moved to Rainbow Town because Rainbow Fish fascinate them, and part of them research centers around them. Tend to vote Green Party.
Teacher (1)	They teach physics and computer science at the local high school. They are a well-informed citizen, but their knowledge has disillusioned them - they consider all politicians to be corrupt and they hate it when they use rhetoric instead of facts. Vote for whichever party is more rational and reasonable.
Local business owner (1)	They own the local grocery store, which earns a decent amount of revenue, but this has been decreasing over the years. They think the fact that there has not been any new development in the area is to blame. Tend to vote Orange Party.
Construction worker (1)	They work under contract for a local construction firm. Outside of construction work, they do odd jobs in home repair and maintenance. They think all the environmental outcry about the baseball construction affecting Rainbow Fish is a hoax. Tend to vote Orange Party.
Baseball fan (1)	They work at Rainbow Town, but baseball is your real passion. They volunteer at middle school and high school baseball tournaments. They have been advocating for the construction of a baseball stadium at Rainbow Town for years. Tend to vote Orange Party.

Table 2. The voting result in the town hall meeting scenario. The undecided vote option was removed for final voting.

	Green Party	Orange Party	Undecided
Initial vote	4	2	1
Final vote	1	6	0